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(56) Documents cited
GB 1561159 A US 4306583 A US 4285498 A

(58) Field of search
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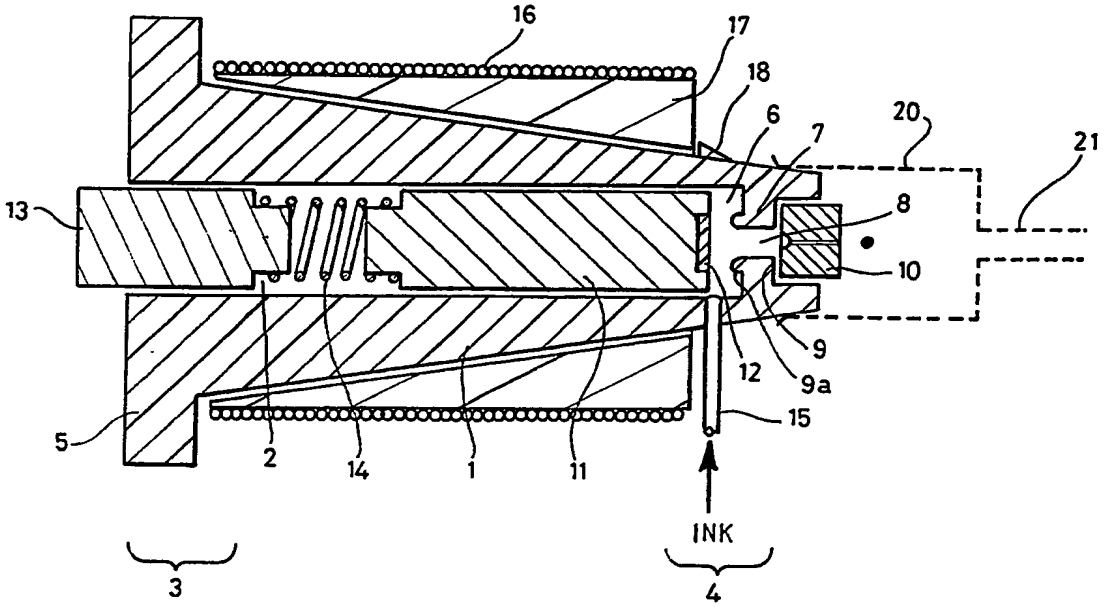
(54) Solenoid valve

(57) A solenoid valve comprising an axially elongated body member 1 having an axial bore therein in which is journalled a plunger member 11 for reciprocation in the bore under the influence of a magnetic field generated by a coil 16 carried by the body member, the body member also being provided with a chamber at or adjacent one end, the distal end, thereof in which the distal end of the plunger can move during reciprocation thereof, the distal end of the chamber being closed by a transverse wall 7 having an outlet 8 therein, the distal end of the plunger being adapted to co-operate with the outlet or the transverse wall so as to prevent or permit fluid to escape from the chamber, is characterised in that the body member 1 is tapered externally towards its distal end, the taper having an included angle of at least 0.75°.

The valve is used in a drop on demand ink jet printer to control the flow of ink to a nozzle outlet thereof.



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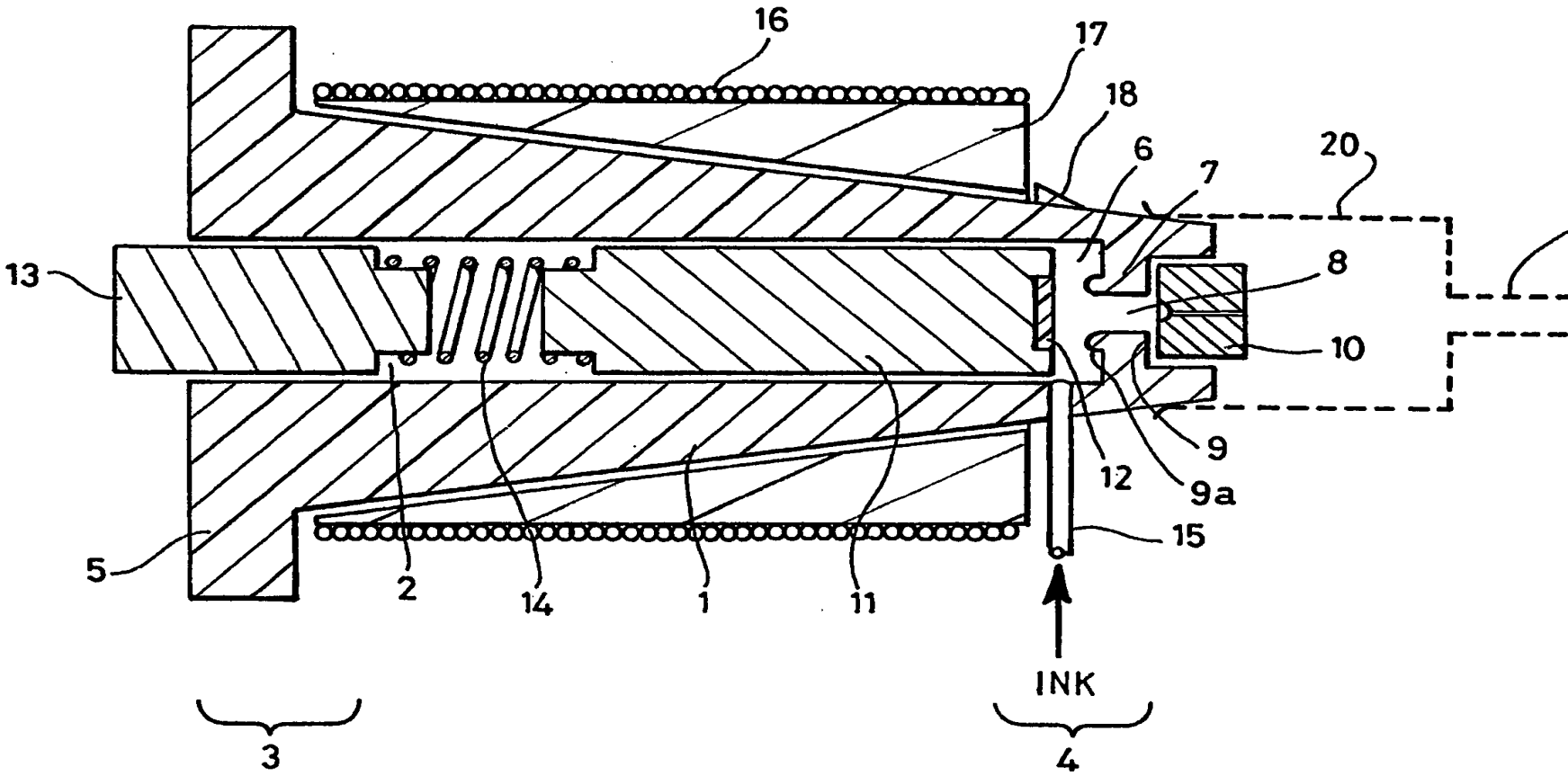
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.


16
17
18
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9a
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INK
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4

TITLE: DEVICE

The present invention relates to a device, notably to a valve for use in an ink jet printer.

BACKGROUND TO THE INVENTION:

In one form of ink jet printer, ink is ejected under pressure through a fine bore nozzle orifice to form a droplet which impinges on the paper or other substrate to form a printed dot. The droplet of ink is formed by opening and shutting a valve controlling the flow of ink to the nozzle orifice. Typically, such valves comprise a tubular body carrying an electrical coil substantially co-axially thereon. Within the axial bore of the body is journalled a plunger for axial movement under the influence of the magnetic field generated by passing a current through the coil. The body carries at one end thereof, the proximal end, a plug which seals off that end of the body and also serves to limit the travel of the plunger in the bore. The other, distal, end of the body carries an ink chamber within which the other, free or distal, end of the plunger travels. A coil spring or other bias means is mounted between the plug and the proximal end of the plunger so as to bias the distal end of the plunger against the inner face of the transverse end wall of the ink chamber so as to close off an axial ink outlet in the end wall. If desired, the distal end of the plunger and/or the inner face of the end wall of the chamber can carry sealing elements, for example co-operating sealing discs, pads or ribs to assist the formation of an ink-tight seal at the ink outlet from the chamber.

For convenience, the term solenoid valve will be used herein to denote in general valve mechanisms which comprise an

body member having an axial bore therein in which is journalled a plunger member for reciprocation in the bore under the influence of a magnetic field generated by a coil carried by the body member; the body member also being provided with a chamber at or adjacent one end, the distal end, thereof in which the distal nd of the plunger can move during reciprocation thereof, the distal end of the chamber being closed by a transverse wall having an outlet therein with which the distal end of the plunger engages in sealing engagement at one extreme of its travel and from which the distal end of the plunger retracts so as to permit fluid to escape from the chamber.

The electrical coil present in such solenoid valves is usually wound upon a plastic bobbin or former which is then slid onto the tubular body member of the valve. The body is usually formed as a plastic moulding and this typically has a very slight taper to it in order to allow the moulding to be removed from the mould in which it is formed. However, this taper is kept to a minimum, typically less than 0.5°, so that the bobbin or former is a close fit upon the body for substantially the whole of its length.

The outlet from the ink chamber of the valve can be in the form of an axial spigot or stubby tube outlet so that the valve can be connected as a push fit to tubing to carry the ink from the valve to a remotely located nozzle orifice outlet. Alternatively, it has been proposed that the valve be connected to a manifold so that the valve can control the flow of ink through a number of nozzle orifices served by the manifold. Again, the valve outlet requires connection to the manifold either directly or via a flexible tube.

We have now devised a form of solenoid valve body which aids accurate location of the electrical coil upon the body and

which facilitates connection of the valve outlet to a wide range of attachments.

SUMMARY OF THE INVENTION:

Accordingly, the present invention provides a solenoid valve mechanism which comprises an axially elongated body member having an axial bore therein in which is journalled a plunger member for reciprocation in the bore under the influence of a magnetic field generated by a coil carried by the body member, the body member also being provided with a chamber at or adjacent one end, the distal end, thereof in which the distal end of the plunger can move during reciprocation thereof, the distal end of the chamber being closed by a transverse wall having an outlet therein, the distal end of the plunger being adapted to engage in sealing engagement with the outlet or the transverse wall at one extreme of its travel and from which the distal end of the plunger retracts so as to permit fluid to escape from the chamber, characterised in that the body member is tapered externally towards its distal end, the taper having an included angle of at least 0.75°.

Preferably, the body member is formed with an internal axial bore and with a terminal recess at the narrow, distal, end of the body so as to provide the internal chamber within which the free, distal, end of the plunger is to co-operate with the transverse end wall of the chamber. It is further preferred that the distal end of the chamber be provided with a transverse end wall and that the internal face of that transverse end wall have one or more axially upstanding sealing ribs adapted to engage with a transverse sealing member carried at the distal end of the plunger journalled for axial reciprocation within the axial bore of the body under the influence of the magnetic field to be generated in

the coil carried substantially co-axially upon the body.

By forming the body as a frusto-conical member, the external surface of the body provides a taper fit into the former or bobbin of the coil and, where the bobbin or former has a corresponding taper, the bobbin or former will seat more securely upon the body than where a truly cylindrical bobbin or former is fitted upon a conventional body.

By forming the chamber as a blind end to the cylindrical axial bore in the body, the body can be formed by a simple moulding process. This avoids the need to provide a separate end cap to form the chamber with the attendant problems of securing a fluid tight seal to the chamber. Furthermore, the sealing ribs on the internal end face of the chamber can readily be formed during moulding of the body, thus aiding simplicity and economies in manufacture of the body of the valve.

The distal end of the body can be extended as a continuation of the taper over the main part of the body so as to provide a spigot member which can be readily be inserted into a female recess in another component to connect the valve body to that component. In view of the external taper on the spigot, a fluid tight seal between the valve and the other component is more readily and consistently achieved than where a conventional cylindrical spigot is used. Furthermore, since the chamber at the distal end of the valve body can extend within the axial length of the spigot member, the valve body of the invention enables a compact assembly to be achieved with other components.

The valve of the invention can be used in a wide range of applications by connecting the distal end to other components using the taper on the distal end of the body

member to provide a push fit connection into a suitable recess in the other component. Thus, the spigot can be a push fit into an adaptor cap which carries a conventional spigot outlet which can be connected to a wide range of conventional other components. By variation of the adaptor cap, a range of sizes of components can be connected to a standard sized valve.

However, the valve of the invention is of especial application in controlling the flow of ink to the nozzle outlets of a drop on demand ink jet printer where the ability to use a standard valve with substantially consistent performance with a wide range of sizes of other components in the ink system of the printer greatly assist the design, construction and initial commissioning of the printer. Accordingly, from another aspect, the present invention provides a drop on demand ink jet printer, characterised in that the flow of ink to a nozzle of the printer is controlled by a valve of the invention.

DESCRIPTION OF THE DRAWING:

To aid understanding of the invention, it will now be described by way of illustration with respect to a preferred form thereof as shown in the accompanying drawing, which is an axial cross-section of the valve body.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

The valve comprises a frusto-conical body member 1 moulded from a suitable plastic, for example a polyester resin. The body has a substantially central axial bore 2 extending from a thicker, proximal, end 3 to the narrow, distal, end 4 of the body. The proximal end 3 can be formed with a radial flange 5 as shown which serves as a shoulder against which

the electrical coil butts when it is mount d on the body member 1. The flange also serves as a mounting means for the valve and can be provided with screw holes or other means by which the valve can be attached to the print head of which it is to form part. The flange can have a circular or polygonal transverse cross-section to suit the mounting into which it is to be located.

The body member 1 tapers towards the distal end 4 to give an included angle of at least 0.75° and preferably at least 1.0 - 2.5°, to the cone of revolution congruent with the surface of member 1. The included angle preferably increases to 5° or more at the distal end of the body to aid insertion of the distal end into other components and to minimise the variation in axial length of the assembly of the valve and other component where there are variations in taper angle or size during to manufacturing tolerances.

If desired, the outer face of body 1 can be formed with, be treated with, or be coated with a high friction or high stiction material to aid retention of the electrical coil upon the taper of member 1. Alternatively, the outer face of the body member can be cut with one or more helical grooves or carry one or more helical ribs to provide a screw thread type of surface to engage with the internal face of the electrical coil to aid location and securing of the coil on the body member.

The interior of the axial cylindrical bore 2 can be provided with axial grooves or ribs, or the bore can be formed with a polygonal cross-section to provide axial passages for the flow of ink past the plunger journalled in the bore as described below.

Preferably, the body 1 is formed with a closed distal end 4

so as to provide the ink chamber 6 in the blind end of the bore 2. The transverse end wall 7 closing the distal end of the axial bore 2 is conveniently formed during moulding of the body member so that it is an integral part of the body member. This avoids the need to provide a separate end wall, for example as an end cap, which must be secured and sealed upon the body member. The transverse end wall 7 forming the blind end to the bore 2 is preferably provided with an axial bore 8 therethrough, which serves as the ink outlet to the ink chamber 6. This bore can be formed during the moulding of the body member or can be formed subsequently.

It is preferred that the bore 8 have a portion of broader diameter adjacent its outlet so as to form an internal shoulder 9 against which a jewel nozzle orifice 10 butts when it is mounted in bore 8 to form the fine bore nozzle orifice for the valve. Alternatively, the jewel nozzle orifice can protrude into the ink chamber 6 to provide a convex seat against which the free end of the plunger seats to close the outlet to chamber 6. The nozzle orifice can also be provided by a capillary tube inserted into outlet 8. The tube can extend into chamber 6 so that its rim provides an annular seat corresponding to the ribs 9a as shown in the drawing.

It is preferred that the nozzle orifice be demountable, for example by being a push fit in outlet 8. Other forms of demountable mounting can be used, for example a screw cap carrying the jewel nozzle or capillary tube orifice can be mounted on an external screw thread on the outer face of the end of the body 1.

The axial bore 2 within body 1 has journalled for axial reciprocation therein a plunger 11 whose free, distal, end

extends into chamber 6 and seals against the end wall 7, the ribs 9a or the protruding end of the jewel or capillary tube nozzle orifice. If desired, the distal end of plunger 11 can carry a sealing disc or pad 12 of a suitabl rubber or resin to provide the sealing seat against the ribs 9a or their equivalent. The extent of rearward travel of plunger 11 is restricted by the end plug 13 located at the proximal end of the bore 2 and whose axial position is set during manufacture of the valve to give the desired travel of plunger 11. Plunger 11 is normally biassed into sealing engagement with the outlet to chamber 6 to prevent the flow of ink through chamber 6 by a spring 14 or other bias means acting between plunger 11 and plug 13. The proximal end of bore 2 can be sealed by seals between plug 13 and the side wall of the bore or by providing an end cap not shown.

As stated above, ink is fed to chamber 6, preferably via a radial inlet 15 into the chamber, as shown. However, the ink may also be fed into bore 2 so that it flows axially past plunger 11 into chamber 6.

Externally upon body member 1 is mounted an electrical coil 16. This can be free standing or, more usually, is wound upon a plastic or similar bobbin or former 17. Preferably, the inner face of the bobbin or former 17 has a taper corresponding to that of the external face of member 1 so that the former or bobbin seats firmly upon the body member as it is pushed axially onto the body member. The coil and bobbin or former are of conventional construction and design, except for the taper on the inner face of the former or bobbin. If desired, means, for example a circumferential rib or snap latch 18, can be provided to retain the coil upon the member 1.

The valve of the invention can be connected to a wide range

of other components by virtue of the taper at the narrow, distal, end of the body member 1. Thus, the valve can be connected to a manifold where the valve is to serve a number of nozzle orifices, in which case the jewel or other nozzle orifice 10 is not inserted in the outlet 8 to body member 1 and the necessary nozzle orifices are provided at the individual outlets to the manifold. By virtue of the taper at the distal end of the valve body, insertion of the distal end of the body into the female recess in such other components is facilitated and a fluid tight seal between the body member and the other components can readily be achieved.

Alternatively, as shown dotted in the drawing, an adaptor cap 20 can be mounted as a push fit onto the distal end of the body member. 21 The cap 20 can have a conventional cylindrical spigot or other outlet by which the valve is connected to other components. In this way, it is possible using a standard valve body member 1 to fabricate a valve which can be adapted to fit a wide range of types and sizes of components and thus provide a versatile valve usable in a wide range of applications.

The above construction of the valve is encased in a metal shell, not shown, to provide the magnetic return for the magnetic field generated as a current is passed through the coil 21. Such a shell typically takes the form of a cylindrical pot into which the valve assembly fits and which is then closed by a metal disc through which the free end of the valve body protrudes so that the nozzle orifice or the adaptor cap or other component can be fitted to the assembled valve.

CLAIMS:

1. A solenoid valve mechanism which comprises an axially elongated body member having an axial bore therein in which is journalled a plunger member for reciprocation in the bore under the influence of a magnetic field generated by a coil carried by the body member, the body member also being provided with a chamber at or adjacent one end, the distal end, thereof in which the distal end of the plunger can move during reciprocation thereof, the distal end of the chamber being closed by a transverse wall having an outlet therein, the distal end of the plunger being adapted to engage in sealing engagement with the outlet or the transverse wall at one extreme of its travel and from which the distal end of the plunger retracts so as to permit fluid to escape from the chamber, characterised in that the body member is tapered externally towards its distal end, the taper having an included angle of at least 0.75°.

2. A valve as claimed in claim 1, wherein the included angle of the taper is from 1 to 2.5°.

3. A valve as claimed in either of claims 1 or 2, wherein the body member is formed with an internal axial bore having a blind end at or adjacent the distal end of the body so as to provide the internal chamber within which the distal end of the plunger is to co-operate with the transverse end wall of the chamber.

4. A valve as claimed in any one of the preceding claims, wherein the distal end of the chamber is provided with a transverse end wall and the internal face of that transverse end wall has one or more axially upstanding sealing ribs adapted to engage with a transverse sealing member carried at the distal end of the plunger.

5. A valve as claimed in any one of the preceding claims, wherein the external surface of the body provides a taper fit into the former or bobbin of the coil and the bobbin or former has a corresponding taper.

6. A valve as claimed in any one of the preceding claims, wherein the distal end of the body is axially extended as a continuation of the taper over the main part of the body so as to provide a spigot member which can be readily be inserted into a female recess in another component to connect the valve body to that component.

7. A valve as claimed in claim 6, wherein the chamber at the distal end of the valve body extends within the axial length of the spigot member.

8. A valve according to claim 1 substantially as hereinbefore described.

9. A valve substantially as hereinbefore described with respect to and as shown in the accompanying drawings.

10. A drop on demand ink jet printer, characterised in that the flow of ink to a nozzle of the printer is controlled by a valve as claimed in any one of the preceding claims.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

GB 9221666.2

Relevant Technical fields

(i) UK Cl (Edition L) F2V (VG6,VP1,VP3,VP5,VS20) H1P (PMB)

(ii) Int Cl (Edition 5) F16K, H01F

Search Examiner

PAM=HYETT

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

3 MARCH 1993

Documents considered relevant following a search in respect of claims 1-10

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1561159 (B.V.H.I. LTD)	1
X	US 4306583 (TUCOULAT) - see Figure 2	1
X	US 4285498 (NIGHTINGALE) - see Figures 1-3	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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